Sensory Evoked Potentials

THE CLINICAL EVALUATION of patients with neurologic problems is subjective and based on semiquantitative data. Computed tomography (CT), other radiologic procedures, electroencephalography (EEG), electromyography and, in the future, nuclear magnetic resonance imaging contribute to the diagnostic acumen. An objective, noninvasive evaluation of specific spinal cord and brain sensory pathways has become available in clinical practice through the application of sensory evoked potential (EP) techniques. Sensory evoked potentials are the electrical responses of the nervous system to specific external stimuli that activate afferent pathways. These potentials are of very low amplitude, which requires that they be extracted from the much larger ongoing EEG activity using computer averaging techniques. Applications of clinical use are (1) cortical visual evoked potentials elicited by reversing pattern stimulation, (2) click-evoked brain-stem auditory evoked potentials and (3) electrically elicited subcortical and spinal somatosensory evoked potentials.

Visual Evoked Potentials

The primary usefulness of visual EPs is in cases of multiple sclerosis because the optic nerve is frequently involved in this disorder, even in asymptomatic patients, and abnormalities tend to persist after clinical recovery. The diagnosis of multiple sclerosis requires evidence of multifocality. Visual EPs often provide that information. In patients without clinical evidence of optic nerve involvement, visual EPs are abnormal in 40% to 50% of cases of possible and probable multiple sclerosis and in 50% to 60% of cases of definite multiple sclerosis. In other lesions of the optic nerve, visual EPs are not as useful because involvement is often clinically apparent or detected more easily by other techniques. Intraoperative monitoring of patients with tumors in or around the optic nerve is helpful in selected patients. Visual EPs are not helpful in the evaluation of coma.

Brain-stem Auditory Evoked Potentials

Brain-stem auditory EPs are not as useful in cases of multiple sclerosis, but the detection rate of silent lesions is still about 20% to 30%. This technique is excellent in the early detection of acoustic neuromas and invasive brain-stem gliomas. The yield in detecting acoustic neuromas, even very small ones not visualized by contrast brain CT scan, is well over 90%. Normal findings on brain-stem auditory EPs, for all practical purposes, rule out an acoustic neuroma. In some selected patients brain-stem auditory EPs are used to monitor the functional integrity of the acoustic nerve during removal of an acoustic neuroma. This technique has not been useful in detecting vascular lesions of the brain stem. In patients in coma, normal brain-stem auditory EPs are highly suggestive that the brain stem is functionally intact. Abnormal evoked potentials in a patient in coma imply that the primary cause of the coma is a structural brain-stem lesion.

Somatosensory Evoked Potentials

Somatosensory EPs are also excellent in detecting silent lesions in cases of multiple sclerosis. In patients without sensory symptoms or signs, somatosensory EPs will be abnormal in 50% with a definite diagnosis of multiple sclerosis, in 55% to 60% with a probable diagnosis and in 40% with a possible diagnosis. These percentages will be even higher when both upper and lower extremity stimulation is used. In addition to cases of multiple sclerosis, somatosensory EPs are sometimes of use to locate lesions in the peripheral nervous system, plexi, roots and spinal cord. Abnormalities will be present when posterior columns or the lemniscal system is involved. Because somatosensory EPs test different structures than brain-stem auditory EPs, they are helpful in evaluating cases of coma. Normal somatosensory EPs and brain-stem auditory EPs in a patient in coma make it extremely unlikely that the cause of the coma is a structural brain-stem lesion. Monitoring spinal cord function with somatosensory EPs in patients undergoing an extensive spinal operation is only feasible in centers with special expertise in this area.

Sensory EP studies can be of help in the diagnosis of neurologic disorders when used in situations as described above. Their indiscriminate use because they are available, relatively cheap and noninvasive should be discouraged.

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Arteriographic, Digital Angiographic and Noninvasive Testing of the Carotid Arteries

JUST TWO YEARS ago intravenous (IV) digital subtraction angiography was touted as a minimally traumatic method that would replace both standard head and neck arteriography and noninvasive tests in assessing disease in the carotid systems. Today it is clear that each neurodiagnostic technique has its place. Standard arteriography provides high-resolution images of the extracranial and intracranial vessels that cannot be achieved yet with IV or intraarterial digital subtraction angiography. The latter offer maximal contrast resolution, whereas the standard arteriographic techniques offer maximal spatial resolution. The noninvasive tests, using primarily ultrasound and plethysmographic methods, are the most sensitive procedures for detecting physiologic changes in the carotid and ophthalmic systems, which one can use to determine the hemodynamic effects of a carotid stenosis and to interpolate residual lumen diameter. Using noninvasive tests to monitor physiology is the safest and most practical way to follow patients for evidence of progression of a carotid lesion.

Although IV digital subtraction angiography is a relatively atraumatic technique and can be done on an outpatient basis, it carries associated local, systemic, cardiac and neurologic risks. Even when done well, the findings may be obscured by overlapping of vessels, poor cardiac output and subtraction and movement artifacts. The frequency of inadequate studies may increase with the occurrence of bilateral and tandem atheromatous lesions. Noninvasive tests are less traumatic and more routinely applicable, but not easy to carry out well. Neither noninvasive tests nor IV digital subtraction angiography provide data by which one can consistently distinguish between an occlusion and very tight stenosis or reliably identify ulcerations in an atheromatous plaque.

Patients with an asymptomatic bruit should be examined first with noninvasive testing. Patients with ischemic events

in one vascular territory in whom noninvasive testing shows no evidence of contralateral or tandem lesions are candidates for IV digital subtraction angiography. If a patient has several signs or symptoms in several vascular territories or evidence of multiple lesions on noninvasive testing, an intraarterial contrast study is recommended. This should be a standard arteriogram unless selective catheterization is difficult. In the latter case, intraarterial digital subtraction angiography can facilitate the relatively rapid acquisition of information on the extracranial or intracranial extracerebral vessels using modest contrast volumes.

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Magnetic Resonance Imaging Versus Computed Tomography

X-RAY COMPUTED TOMOGRAPHY (CT) has revolutionized diagnosis and management. The information gained from CT scans has contributed to a reduction in the number of electroencephalograms, angiograms, spinal taps, plain skull films and isotope scans formerly done largely as nonspecific screening procedures. With the additional tomographic data available from magnetic resonance (MR) imaging, there will likely be a further reduction in these procedures.

A CT scan shows bone, blood and some grey and white matter distinction, but because the possible interactions of x-rays and tissues are limited, very little soft tissue characterization is possible. Magnetic resonance allows the imaging of hydrogen in tissues by applying a complex sequence of fixed and changing magnetic fields to a region of the body. A patient is placed in a very strong, constant magnetic field, several thousand times the earth's magnetic field. While this field is held constant, a high-frequency alternating current (in the shortwave radio range) is superimposed on this main field for a brief period. This excites hydrogen nuclei in the tissues. About two thirds of a body's atoms are hydrogen. The nucleus of the hydrogen atom behaves like a small bar magnet and tends to orient parallel to the main field. When excited by the radiofrequency pulse, some nuclei are driven out of alignment, returning to their original alignment after about one second. During this return, or decay, time they emit a radio signal at a frequency proportional to the magnetic field they are in. By adding and subtracting from the main field by electromagnetic coils placed around the patient, slight gradual changes (gradients) in field strength between two positions within the patient can be made that cause the resonant frequency of the decaying signal to be position-dependent. By this means, location and imaging of hydrogen in the body are possible.

Magnetic resonance excitation is usually by means of a sequenced pair of pulses separated by a brief interval. The computer expects tissue to be in the same place for both. If blood is moving rapidly, it will not be in the same place and will have been replaced by unexcited hydrogens. The chambers of the heart and the lumina of large vessels therefore appear dark. Blood's movement serves as its own contrast medium. It is reasonable to expect that most angiography (including coronary) eventually will be done by this noninvasive method. Within the limitations of patient movement, spatial resolution is as good as the best CT scan. Other characteristics of hydrogen's resonant frequency and rates of decay of the hydrogen signal provide still more information about tissue characterization.

Cortical bone contains very little hydrogen, so it appears black and is invisible on a scan. Many ordinarily obscured soft tissues such as bone marrow, pituitary, posterior fossa, spinal canal and inner ear structures can be seen with unprecedented clarity. Malignant tumors, edema and inflammation can be differentiated clearly from surrounding healthy tissues because tissue water in these regions is not only greater but appears to be relatively unbound to large molecules and cellular structures.

Magnetic resonance imaging produces so much information without the need to inject contrast material that there is little stimulus to develop new contrast media. And because there is no ionizing radiation, magnetic resonance appears to be completely harmless.

At present the greatest limitations of MR imaging are its long scan time (more than five minutes, making it inappropriate for many patients); its high cost (almost twice as much as a CT scanner); its low patient load (about half of that of CT); its complexity of theory, operation and interpretation (an order of magnitude greater than CT); its large space requirement (several times that of CT), and government resistance to this new technology.

The technology of CT was an order-of-magnitude jump over simple shadow radiography. Magnetic resonance appears to involve a similar jump beyond CT because it offers so much more information about tissues without subjecting patients to ionizing radiation. It should not be considered simply an extension of x-ray CT.

Because it is not radiologic in nature and is so complex, MR imaging will offer so much information to so many specialties that the performance and interpretation of this remarkably diverse new clinical probe of tissues inevitably will become interdisciplinary and not confined to any one specialty.

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Percutaneous Glycerol Trigeminal Gangliolysis for Tic Douloureux

TIC DOULOUREUX is a well-known syndrome of facial pain usually characterized by unilateral, paroxysmal, lancinating, electric shock-like pains in the distribution of one or more branches of the trigeminal nerve. The pain is unique in that it is frequently evoked by nonnoxious ipsilateral (trigger zone) stimulation, and neurologic examination shows little detectable trigeminal sensorimotor deficit. Episodes of pain last